THE JOURNAL OF THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

OCTOBER 1961

Volume 55, Number 5 Whole Number 452

THE JOURNAL OF THE
ROYAL ASTRONOMICAL SOCIETY
OF CANADA

Vol. 55, No. 5 OCTOBER 1961 Whole No. 452

WILLIAM ROSS HOSSACK, 1927–1961

By John F. Heard
David Dunlap Observatory, University of Toronto, Richmond Hill, Ontario

On July 10th of this year the Society lost one of its most active and valued members, Dr. William R. Hossack, who, along with his wife, Mary Ann, was killed in a motor accident near Ottawa. Dr. and Mrs. Hossack's five-year-old son, Brian, survived the accident without serious injury.

Dr. Hossack was born in Toronto in 1927. He enrolled in the Mathematics and Physics course at the University of Toronto in 1944 and

graduated in the astronomy option in 1948. He continued his study of astronomy in the School of Graduate Studies, obtaining his M.A. in 1949 and his Ph.D. in 1953. During the session 1953–54 he filled an appointment as Lecturer in Astronomy in the University.

Becoming interested in the specialized field of operational research, Dr. Hossack in 1954 accepted a post in Ottawa with the Department of National Defence. Later he returned to Toronto to continue this same type of work, first with A. V. Roe Canada, Ltd., and, during the past four years, with Stevenson and Kellogg Ltd., Management Engineers. At the time of his death Dr. Hossack was serving his firm as an advisor to the Glassco Royal Commission on Government Organization.

In the field of astronomy Dr. Hossack had particular skill in the design of electronic equipment. His Ph.D. thesis was concerned with the design, construction and use of an oscilloscopic microphotometer which could present instantaneous profiles of spectral lines of two spectrograms side by side in such a way as to make rapid quantitative comparisons of the spectra.

Although Dr. Hossack transferred his efforts to other fields, he never lost interest in astronomy. Not only in his work did he apply his knowledge of the subject to problems in the missile field, but he also maintained an active role within the Society. He was successively President of the Toronto Centre, National Librarian and, at the time of his death, National Treasurer. In this, as in many other activities, including work in his church, he was the type of man who could always be counted on to accept any responsibility which he felt competent to fulfil, and invariably he fulfilled it conscientiously and energetically.

Mrs. Hossack, the former Mary Ann Paul, shared in a particular way, one of her husband's non-scientific interests. She was a talented violinist, he a very competent cellist. Before the birth of their son claimed her whole-hearted devotion as a mother, she and her husband used to accept musical engagements and take part in concert tours.

The Society offers its sincere sympathy to the son, parents, relatives and many friends of this fine young couple.

AN ALL-SKY CAMERA FOR AURORAL PHOTOGRAPHY

By F. R. Park
Radio and Electrical Engineering Division, National Research Council, Ottawa, Ontario

During the First Polar Year (1882–83) scientists were primarily restricted to visual observations of the aurora although simple spectroscopes were used to identify major spectral features. Some efforts were made to determine the heights of auroral displays by simultaneous visual observations at two stations but such observations were fraught with many difficulties and did not provide consistent results. It was not until 1892 that Prof. Martin Brendel obtained successful pictures of the aurora at Bossekop in northern Norway (Harang 1951a). Parallactic photography for the determination of height was begun by Störmer (1955a) in 1910, since when a very large number of such measurements have been made in various parts of the world. Most of these early measurements were made using plate cameras after the design by O. Krogness (Störmer 1955b, Harang 1951b).

Prof. Carl Gartlein (1947) at Cornell University, experimented with an all-sky camera consisting of a ciné camera supported above a convex mirror. This is perhaps the first all-sky camera used in auroral photography.

A wide-angle camera was designed by L. G. Henyey and J. L. Greenstein at the Yerkes Observatory (Osterbrock 1951). Using a small plateholder-type camera and a spherical mirror the instrument had a field of approximately 140° and was first used during the summer of 1950. The plateholder was replaced by a 16 mm. movie camera with single frame operation and used by A. B. Meinel and D. H. Schulte (1953) of Yerkes Observatory in June 1952. Some very fine sequence photographs of auroral displays were obtained with this camera and interest was aroused in its use for studying auroral motions.

In planning auroral observations for the International Geophysical Year, auroral all-sky cameras were designed in several countries. Davis and Elvey (1955) describe a camera which was designed and used at the Geophysical Institute of the University of Alaska. W. Stoffregen (1955a, b) at Uppsala Observatory in Sweden had produced a somewhat different design employing a "folded" optical system (see figure 1). This design was eventually adopted by the United States and Russia in the production of all-sky cameras for use during the I.G.Y. Meek (1955), at the University of Saskatchewan, had designed and built a 16 mm. automatic, all-sky camera employing a "direct" optical system (see

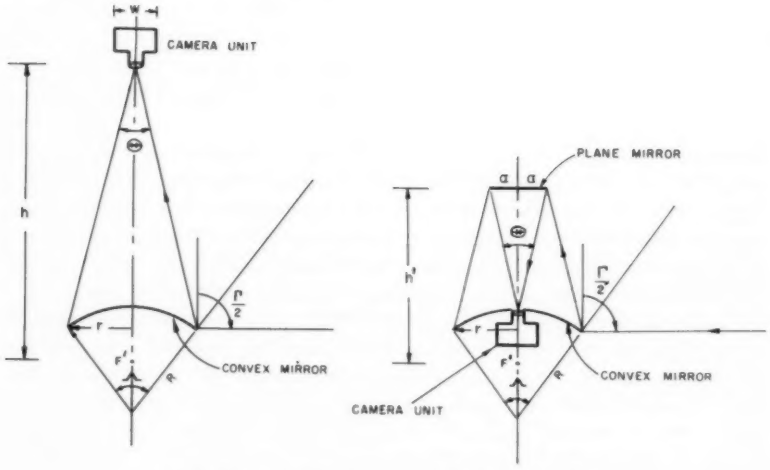

FIG. 1—Optical configurations of all-sky cameras.

figure 1) and this became the basis for design of both 16 mm. and 35 mm. all-sky cameras produced in Canada.

Although the "folded" optical system permits a very compact and sturdy design and provides for enclosure of the instrumentation camera in the base, it introduces several problems not found in the "direct" optical design.

(1) The instrumentation camera sees an image of the spherical mirror reflected in the plane mirror overhead. If this mirror is large enough to include both the spherical mirror and the presentation of date-time information it will obscure a greater amount of the sky than is the case of the direct optical system unless the instrumentation camera is very large.

(2) The use of the "folded" system introduces additional air-glass surfaces with consequent loss of light. If front surface mirrors are used it may become necessary to cover the whole camera with a plastic dome with the consequent introduction of two additional reflecting and scattering surfaces. Since the dome is of plastic it is difficult to maintain its surfaces clean and unscratched. To protect the camera lens, a glass window is used in the centre of the spherical mirror adding two more air-glass surfaces. With the camera lens pointing upward it is more difficult to keep it dust-free.

(3) Lights from below the horizon, which are generally difficult to

control, are scattered by the small plane mirror and produce unnecessary fogging of the film.

Nine 35 mm., automatic, all-sky cameras, generally referred to as Model DA-3, were designed and built by the Radio and Electrical Engineering Division of the National Research Council and operated at selected Canadian stations during the I.G.Y. Figure 2 shows one of these cameras. The electrically-operated instrumentation camera (Canadian Applied Research Type T232-MKVII) is mounted above the spherical

FIG. 2—Model DA-3 auroral all-sky camera.

mirror so that it sees an image of the sky from horizon to horizon. The timing and controlling unit is contained within the cast aluminum base. Date-time, exposure duration and station identification are presented beside the mirror through a plastic window and photographed in each picture. An altitude marker light is located on each of the four camera-supporting legs so as to produce fiducial points, 15 degrees above the horizon for purposes of altitude calibration. The instrumentation camera employs a plug-in magazine which holds a 100-foot roll of 35 mm. film, sufficient for 24 hours of night-time operation.

The "direct" optical system (figure 1) is used in the DA-3 all-sky camera. The spherical mirror is a commercial-grade, second-surface, stock size, mirror manufactured by the Bausch and Lomb Optical Company. It has a radius of curvature of 9.75 inches and is 13 inches in diameter. The front surface produces multiple reflections of the brightest stars but these are not objectionable.

The lens is a Fujinon, 50 mm. focal length lens operating with a focal length to aperture ratio of 1.2. The speed of the camera for extended surfaces is simply the speed of the lens but for point sources such as stars, the effective aperture of the lens-mirror system must be considered (McNamara 1957). In the DA-3 camera the effective aperture is less than the maximum lens aperture by a factor of 8.5 so that the effective speed for stars is about 1/70 that for aurora. However, with Eastman Kodak Tri-X film, 5th magnitude stars are visible in a 40-second exposure.

Figure 3 is a view of the underside of the all-sky camera base showing the timing and controlling or date-time unit. It is hinged at one side so that it can be swung downward for minor adjustments or removed completely for servicing. The heart of this unit is the clock-timer mechanism shown at the top of the picture. The numerical clock is a commercial unit (Wickes Engineering and Construction Company, Model 24H-3) rather extensively modified to drive the cams and switches that determine exposure rate and duration, to provide an appropriate motion once per day to advance the day counter (Veeder Root Cat. No. A112733) one digit at midnight and to drive two "24-hour" cams to turn the camera "on" at dusk and "off" at dawn. The dawn and dusk switches can be individually set to operate at any time in the 24 hours. Since one roll of film will serve one, two or three nights depending on latitude and the season of the year, it seemed an unnecessary refinement to turn the camera "on" and "off" by photoelectric cell. The lower part of the controlling and timing unit, consisting of two small panels, contains the camera power supply (24 volts d.c.) and the necessary relays, controls and connectors.

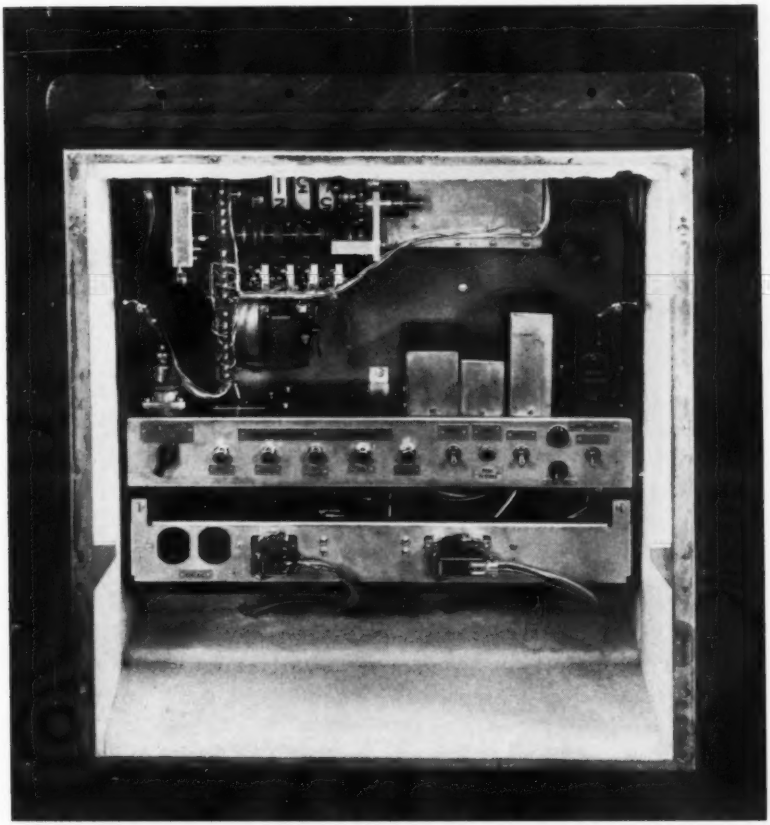

FIG. 3—Timing and controlling unit for Model DA-3 auroral all-sky camera (viewed from underside).

When supplied with 1-minute time pulses from a master clock, the timing and controlling unit causes the camera to take one exposure per minute and provides date, time and other identifying data that are recorded in each picture. A choice of either 4-second, 40-second or alternating 4- and 40-second exposures is available and selection can be made through a simple control. This feature has proven valuable at stations within the auroral zone where very bright, rapidly changing auroras frequently occur.

Power and timing pulses are fed to the all-sky camera from a small

control-panel (not illustrated) which can be located conveniently in an adjacent building or office. The control panel provides facilities for monitoring the operation of the camera.

The all-sky camera can be mounted in a number of alternative arrangements. In general, a flat roof deck or small tower, sufficiently high to be above drifting snow is satisfactory. The transit case for the instrument can serve as a convenient mounting base and, in addition, provide shelter for the operator when servicing the timing and controlling unit. This system was employed at several stations during the I.G.Y. Figure 4

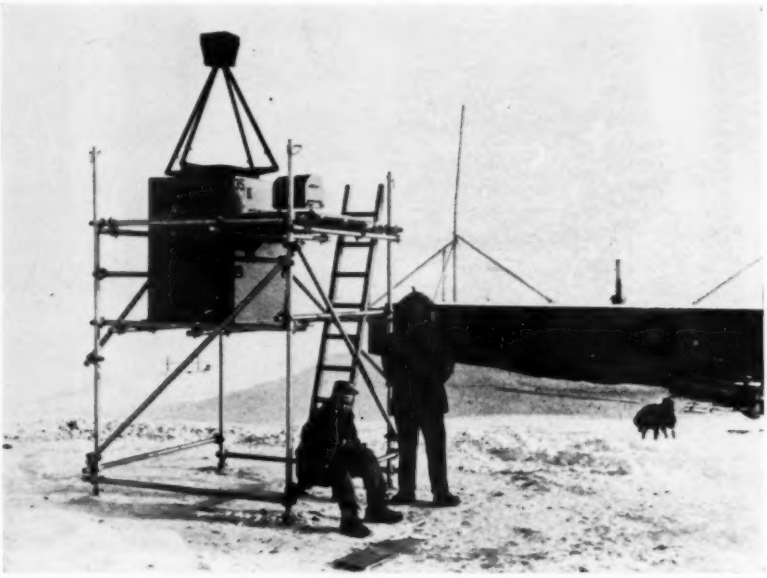

FIG. 4—Model DA-3 auroral all-sky camera mounted at Alert, N.W.T., 82.5° N., within 500 miles of the north pole.

shows the installation of the DA-3 all-sky camera at Alert, N.W.T., 82.5° N. latitude. This was the most northern land-based station during the I.G.Y. Through the use of foam insulation and thermostatically controlled heaters, the camera has operated satisfactorily throughout a wide range of climatic conditions.

Figure 5 shows a sequence of pictures reproduced from the 35 mm. film record of the camera located at Saskatoon, Saskatchewan. The serial date, day 272, corresponds to September 29, 1957, day one being

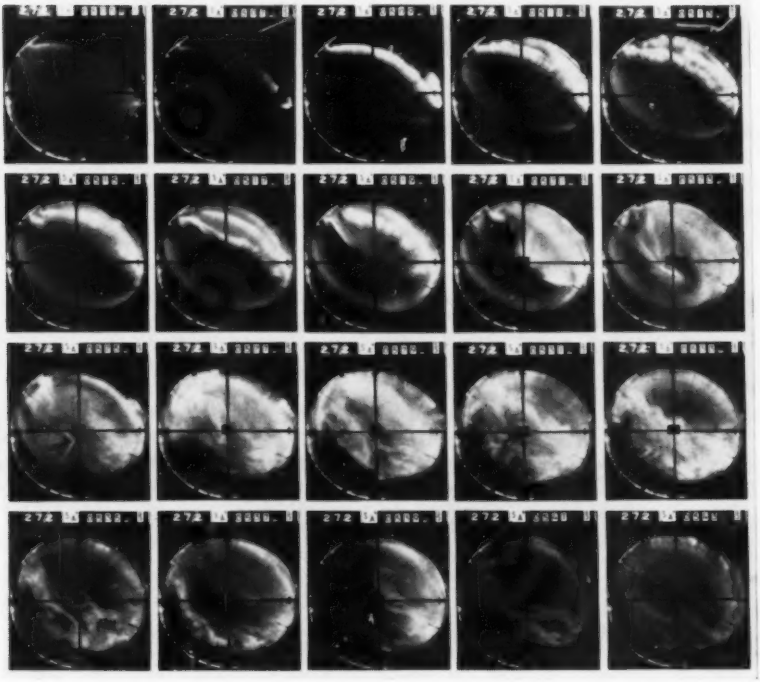

FIG. 5—Sequence of photographs taken from record of Model DA-3 auroral all-sky camera located at Saskatoon, Saskatchewan.

January 1st of that year. In these pictures as in the records of all stations, the time shown is universal time. The letters "SA" in the centre designate the station and the letter "S" in the upper right-hand corner indicates that these are the "short" or 4-second exposures. During this display the aurora was so bright that the "long" or 40-second exposure greatly overexposed the film.

All of the film exposed in the DA-3 cameras is in 100-foot rolls. During the I.G.Y. 1,454 rolls were received from the nine camera stations and 763 rolls from four cameras operated during the I.G.C. (1959). The films were processed to a gamma of 0.65 in D76 developer under carefully controlled conditions by a commercial firm. A film-previewing machine was used to examine the negative and the time and distribution of auroral displays were tabulated. Aurora was recorded on 1,309 of the total of

2,217 rolls (about 59 per cent.) and first-copy, fine-grain, positive-master prints of these rolls were obtained and sent to each of the three World Data Centres. Duplicate negatives, which are indistinguishable from the original negatives, can be made from these positive-master prints.

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THE PATHS OF SOLAR ECLIPSES

By Charles H. Smiley and Fred F. Czarnec
Brown University, Providence, Rhode Island

In astronomy textbooks, when describing the paths of solar eclipses, reference is often made to Th. von Oppolzer's "Canon der Finsternisse" (1887). The Canon contains the elements of solar and lunar eclipses between 1207 B.C. and 2162 A.D., and also maps showing the approximate paths of many of the total and annular solar eclipses during this interval. Specifically, elements are given for 8,000 solar eclipses from 1207 B.C., November 10, to 2162 A.D., November 17, inclusive; and 5,200 lunar eclipses from 1206 B.C., April 21, to 2163 A.D., October 12, inclusive. (Dates before October 4, 1582 A.D. are according to the Julian calendar; later dates are according to the Gregorian calendar.) This gives us a ratio of solar eclipses to lunar eclipses of 20 to 13. All these objective facts are correct and need no elaboration. In looking more closely at Oppolzer's Canon, two weaknesses of the maps become apparent. In this paper we shall discuss these two deficiencies of the maps, and shall show how improved maps may be constructed using the elements given in the Canon.

The first of these shortcomings is the distortion that is unavoidably introduced by using an equidistant projection centred on the north pole, and covering areas on the earth down to 30° south latitude. The second is the result of the use of a circle through three points of the path, the beginning, the middle, and the end, as an approximation to the true path. The existence of these deficiencies was pointed out in an article by Isabel M. Lewis, "A Test of the Accuracy of Oppolzer's Eclipse Predictions" (1933).

We shall begin our study of the maps by visualizing the way in which the moon's shadow moves across the earth at the time of a total solar eclipse. Viewing the earth from the sun, the observer would note that the apparent path of the centre of the moon's shadow on the earth's surface would approximate a straight line. To construct this path geometrically, we must recognize three important and elementary facts: the nearly spherical shape of the earth, the eastward rotation of the earth, and the eastward course of the shadow. To take into account the orientation of the axis of the earth with respect to an observer on the sun, we shall examine four basic cases corresponding to four times of the year, namely March 21, June 21, September 23, and December 21. For simplicity's sake, we shall here limit ourselves to paths near the earth's equator. Figure 1 shows the earth as viewed from the sun about March 21. It will be seen that the eclipse begins at sunrise in the west, and the shadow

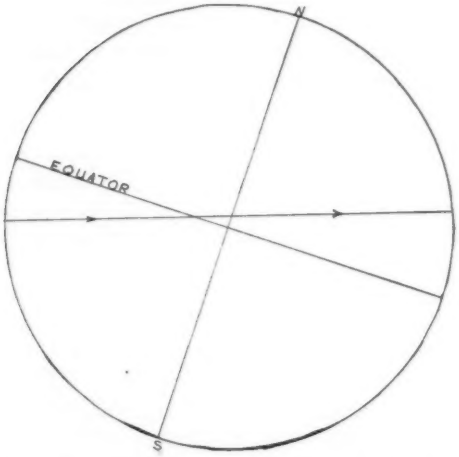

FIG. 1—The relation between the path of a total eclipse and the equator around March 21.

moves in approximately a straight line; in this diagram, the eclipse begins in the southern hemisphere. As the shadow approaches the point where the eclipse will occur at noon, it will move northward to the equator.

The axis of the shadow cone will strike the earth at *A* in figure 1, and will move rapidly more or less parallel to the equator as viewed from a point to the left of *A* (see figure 2*a*) for this view. Viewed from directly in front of *B*, the centre of the shadow will then move across the earth in a north-easterly direction, crossing the equator as shown in figure 2*b*. Finally, the shadow's centre will move off the earth rapidly, describing at the end a line more or less parallel to the equator as shown in figure 2*c*. When plotted on a Mercator projection, the path resembles a segment of a sine curve or an *S* leaning forward (see figure 2*d*).

To explain the difference in speed of the shadow at different points of the path, we shall remind the reader that the moon's shadow is traveling eastward at about 2,100 miles per hour, and that an observer on the equator is being carried eastward by the earth's rotation at about 1,040 miles per hour. To an observer at *A*, the moon's shadow seems to drop down out of the sky; its speed, measured along the earth's surface, may be as much as 5,000 miles per hour. An observer stationed at *B* will see the shadow pass, going eastward at about 1,000 miles per hour (2,100 minus 1,040). If this observer could travel along with the shadow in a jet plane capable of speeds greater than 1,000 miles per horu,

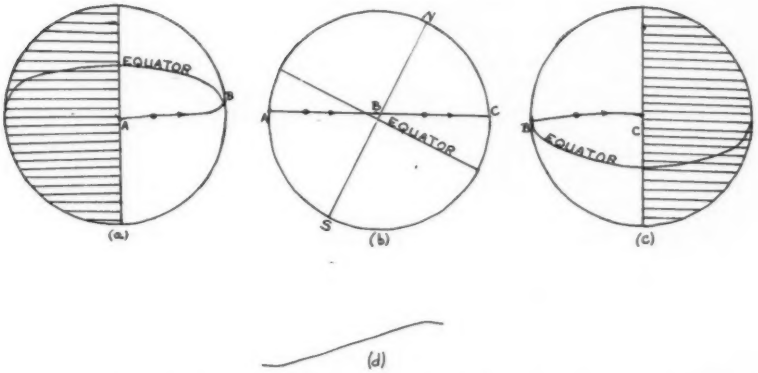

FIG. 2—The path of a total eclipse around March 21, viewed as it (*a*) begins, (*b*) crosses the equator, and (*c*) terminates. Figure 2*d* represents the path on a Mercator projection of the earth.

he would be able to observe a solar eclipse in the total phase for an hour or more, as compared to seven minutes thirty-one seconds maximum duration of totality for an observer at a fixed position on the equator. The situation at C is similar to that at A, except that the shadow will be speeding up instead of slowing down.

The situation on September 23 is indicated in figure 3, only now the path starts above the equator and ends below and, in general, the shape is that of an S reversed and leaning backwards. One sees at once why a circle through three points on one of the paths corresponding to March 21 or September 23 will be a poor approximation to the path. In examining the pattern of the paths for June 21 (figure 4*a*) and December 21 (figure 4*b*), we see that they again resemble parts of a sine curve and that these parts can be better represented by circles than those for March 21 and September 23.

One can obtain an improved map of the central line of a solar eclipse by using the elements given in Oppolzer's Canon. In a horizontal line running across two pages, 26 elements are given. Of these, only nine need be copied out for use, namely:

$$\log \gamma,\ \mu,\ \log n,\ G,\ K,\ \log \sin g,\ \log \sin k,\ \log \cos g,\ \log \cos k.$$

In addition, it will generally be wise to copy down the number in Oppolzer's Canon for identification purposes. It is suggested that four-place logarithms be used, since the elements in the Canon were planned for use with logarithms. A table giving the logarithms of the sine, cosine, and tangent of angles given in degrees and decimals of a degree, such as "Tafel

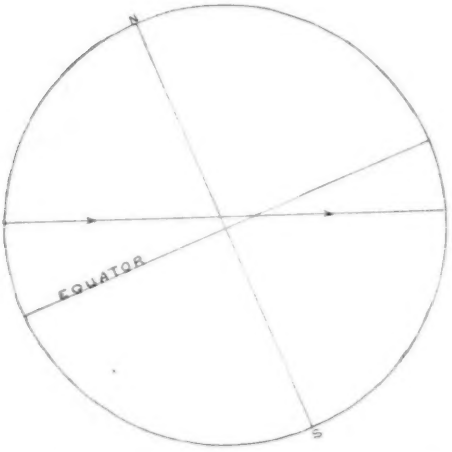

FIG. 3—The relation between the path of a total eclipse and the equator around September 23.

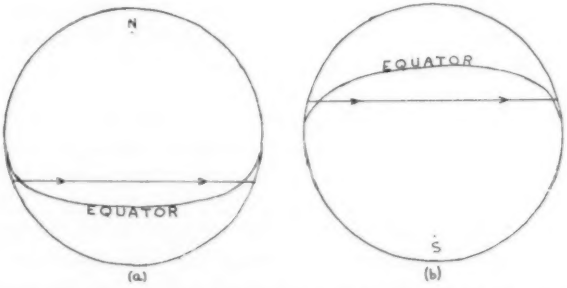

FIG. 4—The relation between the path of a total eclipse and the equator around (*a*) June 21, and (*b*) December 21.

Vierstelliger Logarithmen," by Dr. Carl Bremiker (1874), or "Computation Rules and Logarithms," by Silas W. Holman (1898), is to be recommended.

Four auxiliary quantities, π, ρ, σ, and ω, are computed by means of the equations:

$$\pi = \sin g/[(1 - c)\cos g], \qquad \rho = \gamma/[(1 - c)\cos g],$$
$$\sigma = 15(1 - c)\cos k/n, \qquad \omega = 15 \sin k/n,$$
$$\log 15\,(1 - c) = 1.1746,\ \log 15 = 1.1761,\ \log (1 - c) = 9.9985 - 10.$$

For each point of the central line, a value of t (local hour angle of the sun) is assumed; minus values of t will yield points where the eclipse will be seen in the morning, and plus values, points in the afternoon. The value of $t = 0$ will lead to the point where the eclipse will be greatest at local noon. One proceeds to calculate with this value of t in the following equations:

$\tan A = \pi \sin (G + t)$; $\cos A$ is always positive;
$\sin (\phi_1 - A) = \rho \cos A$,
$\phi = \phi_1 + (\phi - \phi_1)$; the values of $(\phi - \phi_1)$ are obtained from Table I below;

$\tau = \mu - \sigma \sin \phi_1 - \omega \cos (K + t) \cos \phi_1$,
$\lambda = \tau - t$; λ = west longitude.

It should be noted here that these equations are set up in such a way that a positive λ will correspond to a west longitude, a negative to an east longitude. Oppolzer uses the opposite conventions; this must be remembered when one refers to the co-ordinates of the beginning, middle, and end points of the path as listed to the extreme right in the Canon. The novice will find it desirable to start with $t = 0$ and see if he reproduces the mid-point as given in the Canon.

In the critical table given below for correcting ϕ_1 to obtain ϕ, the values given have been computed using a modern estimate of the flattening of the earth.

As an example of the use of the elements in Oppolzer's Canon, the determination of a point on the central line for the eclipse of March 7, 1970, in the Carolinas is carried out (see Table II). In figure 5, a portion of the corresponding map from the Canon is reproduced, and in figure 6

TABLE I

$\pm\phi_1$	$\pm(\phi - \phi_1)$	$\pm\phi_1$
0°.00		90°.00
1.48	.00	88.52
4.46	.01	85.54
7.48	.02	82.52
10.71	.03	79.29
13.86	.04	76.14
17.32	.05	72.68
21.11	.06	68.89
25.42	.07	64.58
30.77	.08	59.23
39.72	.09	50.28
50.28	.10	39.72

In critical cases, take the numerically larger corrections.

TABLE II

$t = 50$	$K + t = 142°.00$
$G + t = 155°.62$	
	$\log \sigma = 0.3952$
$\log \pi = 9.5947$	$\log \sin \phi_1 = 9.9042$
$\log \sin (G + t) = 9.6158$	$\log \mathrm{I} = 0.2994$
$\log \tan A = 9.2105$	
	$\log \omega = 1.4315$
$\log \rho = 9.8481$	$\log \cos (K + t) = 9.8965$
$\log \cos A = 9.9944$	$\log \cos \phi_1 = 9.7762$
$\log \sin (\phi - A) = 9.8425$	$\log \mathrm{II} = 1.1042$
$\phi - A = 44°.09$	$\mu = 127°.37$
$A = 9°.23$	$-\mathrm{I} = -1°.99$
$\phi_1 = 53°.32$	$-\mathrm{II} = 12°.71$
$\phi - \phi_1 = .09$	$\tau = 138°.09$
$\phi = 53°.41$	$t = 50°.00$
	$\lambda = 88°.09$

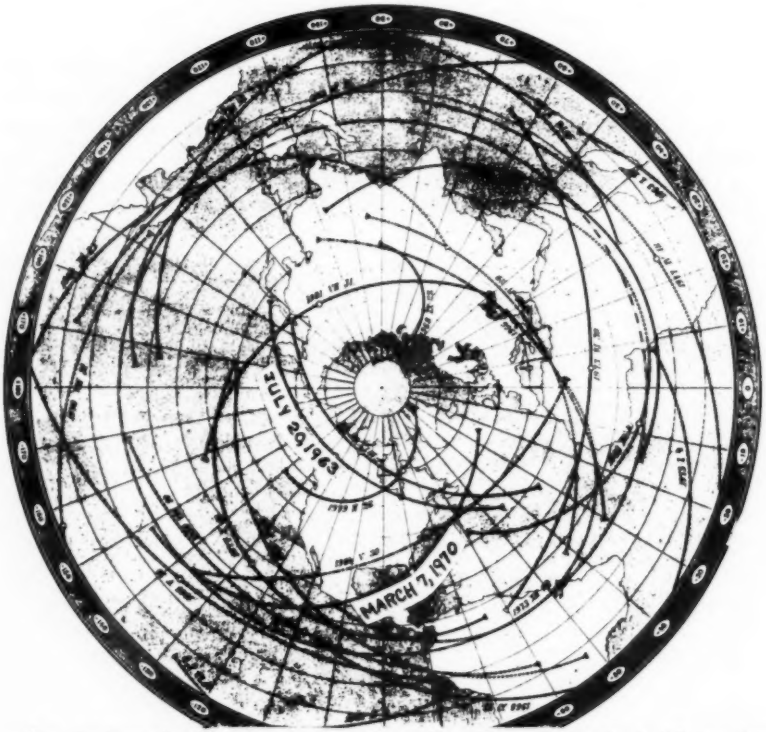

FIG. 5—Reproduction of a map of eclipses from Th. von Oppolzer's "Canon der Finsternisse" showing the paths of the total eclipses of July 20, 1963 and March 7, 1970.

FIG. 6—Map of North America, showing the paths of the total eclipses of July 20, 1963 and March 7, 1970, as computed from Oppolzer's Canon.

is found a map of North America on a modern projection with the paths for the eclipses of 1963, July 20, and 1970, March 7, as computed from the Canon. As Mrs. Lewis has pointed out, paths computed from Canon elements are likely to be within about 15 miles of the true path.

Oppolzer's Canon has been out of print for many years, but photostatic or microfilm copies of the required pages can be obtained from a number of reference libraries. It is to be hoped that a reprint of this very useful book will be made in the near future.

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THE BRUDERHEIM METEORITE—FALL AND RECOVERY

By R. E. Folinsbee* and L. A. Bayrock†
*Department of Geology, University of Alberta, Edmonton, Alberta
†Research Council of Alberta, Edmonton, Alberta

Abstract

Bruderheim, a detonating bolide, entered the earth's atmosphere at 1:06 a.m., M.S.T., March 4, 1960, creating a flash visible for 200 miles, followed by detonations resembling a sonic boom audible over an area of 2,000 square miles. Ten reliable sightings and many flash-sound intervals assisted in pinpointing the fall area. The fireball, travelling on an azimuth of N. 100°, slope 40°, in the direction of the earth's revolutionary path, had an initial atmospheric velocity of about 8–10 miles per second, facilitating entry. More than 300 kilograms fell as individuals within a well-defined ellipse of fall at latitude 53° 54′ N., longitude 112° 53′ W. This ellipse is 3½ miles long and 2¼ miles wide (5.6 by 3.6 km.), with its long axis N.80° W. and the larger individuals located near the south-east apex of the ellipse. Falling vertically onto frozen ground at terminal velocity, most individuals rebounded onto the snow surface, facilitating recovery. Mapping and recovery were continued during the spring break-up period, yielding the university a total of 188 sizable gray chondritic meteorites weighing 303 kilograms. The largest individual weighed 31 kilograms; 500 recovered individuals, each smaller than 100 grams, are uncatalogued.

Introduction and Acknowledgments

Bruderheim, a gray chondritic meteorite which fell on March 4, 1960, at 1:06 a.m. Mountain Standard Time, is, in aggregate weight (over 300 kilograms), Canada's largest known meteorite (Millman 1953). By strange coincidence the bolide detonated halfway between the point where the Edmonton meteorite was found, and the Abee meteorite fell (figure 1). At 1:06 in the morning the late show on television had just finished, a factor adding substantially to the number of eye witness accounts. Bruderheim is a typical evening meteorite, solving the entry problem by reason of its relatively low atmospheric velocity (figure 2).

This paper will deal principally with the fall of the meteor and recovery of the meteorite; chemistry and mineralogy of the stones will be considered in a later report.

Earl Milton, past president of the Edmonton Centre of the Royal Astronomical Society of Canada, was instrumental in alerting the public through the media of press, radio and television, to the possibility that a meteorite fell from the bright detonating bolide. He obtained eye witness reports that narrowed down the possible fall area. Stanley Walker and Tyrone Balacko of Fort Saskatchewan, following a lead given by recovery of a single fragment, mapped the principal fall area in outline, and recovered about 75 kilograms of meteorite in the two days

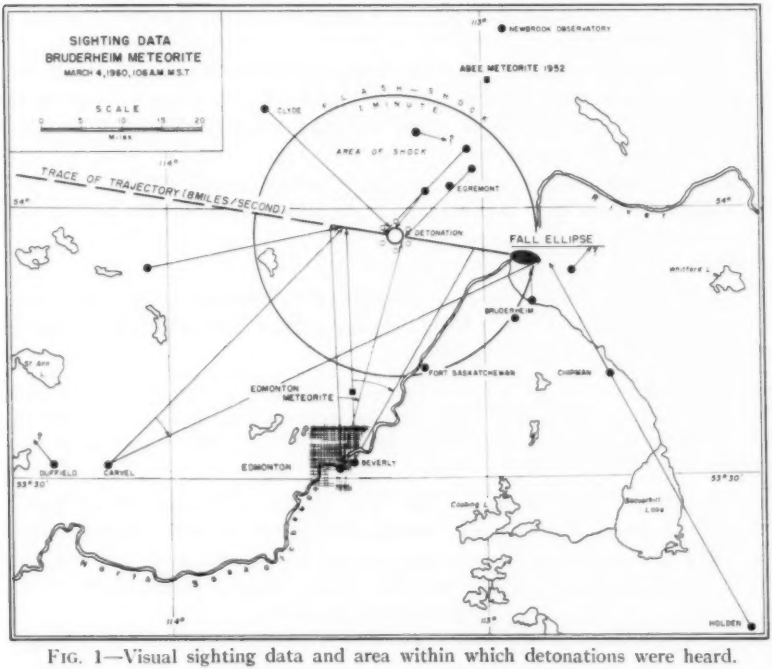


FIG. 1—Visual sighting data and area within which detonations were heard.

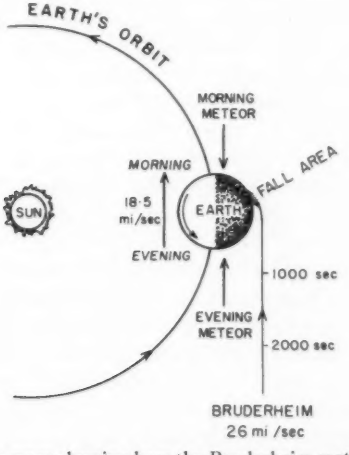


FIG. 2—Schematic diagram showing how the Bruderheim meteorite fell. Bruderheim, an evening meteor, solved the entry problem by reason of its low atmospheric velocity (after Whipple 1957).

immediately after the fall. Heavy snow then fell, and no further recoveries were made till spring.

The farmers of the Bruderheim area co-operated in the search for fragments and made their finds available to the University of Alberta, where special funds were provided by the President, W. H. Johns, for acquisition of the meteorite.

R. S. Taylor assisted in mapping the ellipse of fall. F. Dimitrov drafted the illustrations. All this assistance is gratefully acknowledged.

Fall

The Bruderheim bolide was probably first observed by Alexis Simon, an Indian of the Paul's Band Indian Reserve at Duffield, Alberta (figure 1). His account is as follows:

> On the night [*sic*] of Friday, March 4th, 1960, I happened to be outside of my home at midnight when I saw a large meteorite in the north-westerly direction from Duffield. It lighted up the sky as it passed swiftly in a north-easterly direction, giving off what appeared to be flashes of fire.

He describes also a rushing sound, resembling a high wind, which lasted for 5 to 6 seconds after the fireball passed, a phenomenon distinct from the shock-wave detonations accompanying meteorites, and characteristic of reports of fireballs (Smith and Hey 1952). It may be primarily due to suggestion, without real existence (Heard 1949).

It is interesting to speculate that the more acute senses of Alexis Simon enabled him to observe the meteorite during the time when it first was entering the atmosphere, and to note a sound phenomenon not recorded by other observers whose vision and hearing, dimmed and dulled by television, were quickened only by the bright glare of the fireball lower in the atmosphere, and shaken by the sonic boom at detonation point. However, more prosaically, there was considerable patchy overcast in the Edmonton area, and at Newbrook, though the all-sky camera was on and recorded the general brightening brought about by the bolide at 1:06 a.m., the meteor cameras were not operating (Jack Grant, Newbrook, personal communication).

Mrs. P. I. B. Wood of Carvel (figure 1) observed the fireball from point of detonation to disappearance, as did a number of observers from the slightly overcast city of Edmonton. The most accurate observations of which the writers have record were made from Edmonton by D. B. Russell, a student at the University of Alberta, and from Beverly by M. Reis at the Texaco Oil Refinery. Cross sighting was made by S. E. J. Mitchell of Clyde and by a number of observers near Egremont and in Fort Saskatchewan (Miller 1960).

Some of the sighting and sound data from the Egremont district suggested a fall area north-east of this village: flash sound intervals were small, averaging 20 seconds (from seven observations where time could be judged by repeating motions). L. A. Bayrock and R. S. Taylor spent considerable time in air and ground searches in this area on March 6th and 8th, and as late as April 4th, with negative results. The theory that the Bruderheim bolide had an initial north-easterly trajectory, and at the detonation point split into two main masses, one travelling approximately north 20° east over Egremont, the other 100° (10° south of east) to fall in the Bruderheim area, while plausible, has not been substantiated by finds. The assignment of an azimuth of north 100° to Bruderheim (figures 1, 3) is based largely on the shape of the ellipse of fall and on the

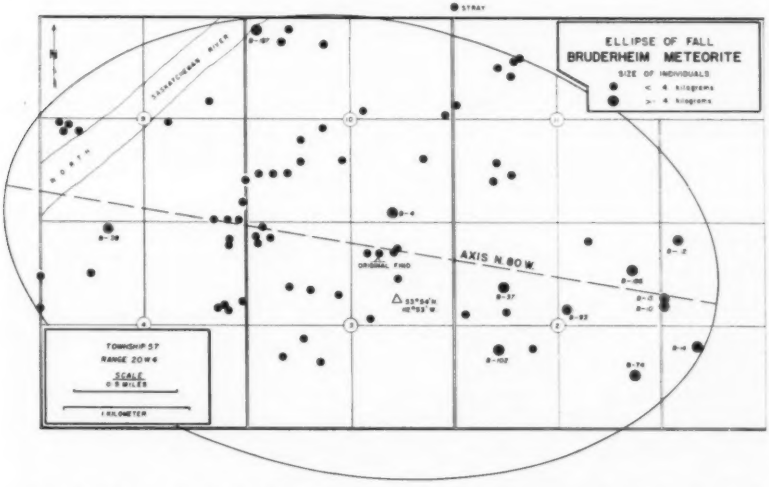


FIG. 3—Mapped individuals from the Bruderheim meteorite define an ellipse of fall.

fact that most of the sighting evidence does not directly contradict such an interpretation. One hundred miles east of the fall area, on this 100° azimuth, Mr. and Mrs. A. C. Butz of Dewberry observed the flash and "... about two to three minutes after light, a thundering noise was heard, windows rattled. ..." This is the outer limit of sound reports.

Though it is clear that the bolide first became brightly illuminated almost directly north of Edmonton, reports of its height at this time vary greatly, and the slope of the path and the geocentric velocity needed for calculation of the radiant, or direction in space from which the body was

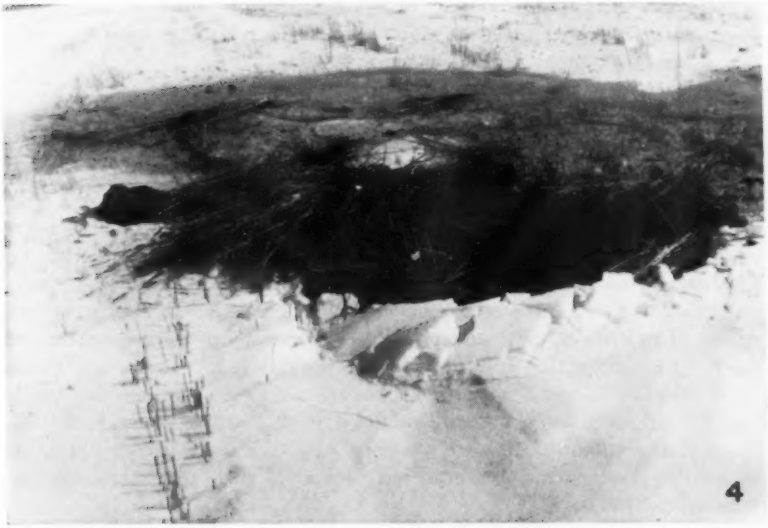
coming, are not easily judged. The best evidence suggests that at a height of about 30 miles the fireball flared a bright blue-white, of sufficient intensity to attract the attention of ground observers, and continued in this halo of plasma-type illumination for 25 air miles to the detonation point at a height of 16–17 miles. Fragments thrown off at detonation remained bright, though changing from white to red as they approached the ground point, about 25 air miles east of the point of detonation. The slope of the illuminated path therefore was about 40°, and since most observers recorded a 5–6 second duration for illumination, the geocentric velocity was about 8–10 miles per second. This interpretation is a best fit interpretation of available sighting data. Heard (1949) describes a fireball similar in many respects to Bruderheim, and gives the equations necessary for solution of the meteor's path in space, given azimuth, slope, and geocentric velocity.

It becomes clear, on examining the university report forms (based on a Russian example), that these were too complex for an unskilled observer. Most of the forms that were turned in provided little more enlightenment than this initial letter received from John Mandryk of Bruderheim:

"I have seen the light and heard the crash. If you wish to send me a form I shall answer it to best of my ability."

Recovery

Nick Broda, a farmer of the Bruderheim district, recovered the first stone from his barnyard on Friday, March 4. It was brought to the Sherritt Gordon Nickel Refinery at Fort Saskatchewan by an employee, and identified as a meteorite. S. Walker and T. Balacko proceeded to the area and began systematically to map the fall and recover fragments which, upon striking frozen ground, had rebounded onto the hard-packed snow surface where they became clearly visible from district roads (figures 4, 5). On Saturday and Sunday, March 5 and 6, Walker and Balacko mapped and collected a total of 155 pounds of meteorite, which they later made available to the university as the nucleus of its collection. At the same time district farmers collected fragment B-74 (figure 1), a complete individual weighing more than 25 kilograms. This stone was then broken by the collectors into a number of fragments, and widely distributed. Most of these pieces mere ultimately acquired by the university, and since B-74 was a completely unweathered specimen it was used as the source of all samples employed in analyses of the meteorite. Andreas Bawel and Walter and Nick Holowaty of Bruderheim collected about 10 kilograms of fragments from their farms on March 4, 5, and 6. Walter Holowaty made the first collections off the ice on the North Saskatchewan River, digging down through the snow to the ice surface



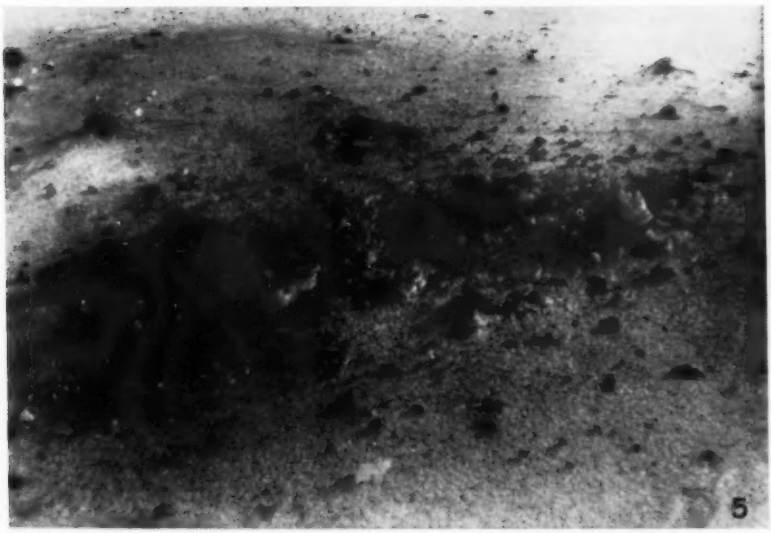


FIG. 4—Looking east at the impact crater formed by Bruderheim individual B-12 which fell in a field of swathed wheat. (Photograph by Walker and Balacko.)

FIG. 5—Bruderheim B-10, which fell on fallow ground. (Photograph by Walker and Balacko.)

wherever he observed an impact hole. On March 7 it snowed heavily and no further recoveries could be made until spring, with the exception of a few small fragments collected from snow banks.

With Walker and Balacko's map of the general fall area as a guide, a concerted effort was made during spring break-up to complete the recovery. Legal opinion held that meteorites on the surface were probably the property of the user of the land and every effort was made to get the farmers to bring in this early crop. Systematic sweeps of the fall area with groups of geology students convinced the writers that local residents could do this more efficiently, and the majority of specimens in the university collection were purchased from Bruderheim farmers. University collecting concentrated on the ice surface of the North Saskatchewan River. Hundreds of grit- and pebble-sized fragments were collected off the river ice, collection continuing up to the day before break-up. These small fragments could not be successfully collected against the black background of stubble and fallow fields in the area and undoubtedly many thousands of them were plowed under. While preparing the fields for seeding, district farmers collected additional large specimens, further defining the fall area.

Title to the Walker-Balacko collection was ensured by settling with the farmers on whose fields these fragments were collected, and an effort was made to purchase as many other fragments as could be obtained at a reasonable price. The Geological Survey of Canada, interested in the fall for the National collection, refrained from competition, and a 40-kilogram suite of especially fine material was made available for this collection at cost.

Bruderheim individuals struck the ground almost vertically, apparently at terminal velocity, perhaps 200 miles per hour at impact. The largest fragments (Table I), weighing 30 kilograms, travelled farthest, and are grouped at the south-east apex of the ellipse. They dug holes about 8 inches deep in the frozen ground and then rebounded onto the snow surface, ending up about 6 to 8 feet east of the impact point, with a shower of dirt splayed south-east of the impact craters. One individual fell onto a cushion of swathed wheat (figure 4). The position of these large individuals confirms the 100° azimuth traced by the fireball, coincident with the axis of the ellipse of fall.

Point of impact of the larger fragments (greater than 4 kilograms) was surveyed with a plane table. Smaller individuals were plotted from the Walker-Balacko map, from mapping on aerial photos while collecting, and from all reliable information obtained from farmers in the area.

The Bruderheim bolide continued breaking up into smaller fragments even after the initial detonation at high altitude, and in this and other

respects the fall resembles Tenham (Spencer 1937). A small but significant number of fragments, perhaps 10 per cent. of the individuals, show partial fusion crusts, in one instance three stages, late-formed fragmentation surfaces that are not completely blackened. There is evidence from the fall pattern that some individuals broke into two or more pieces while still in the air, though travelling below the speed at which fusion crust would form.

In the case of the smaller individuals, direction of fragments from pits is almost random, though there is a suggestion of it being outward from the centre of the ellipse. This probably represents motion imparted by the detonations. These smaller individuals in some cases rebounded onto the snow surface (figures 6, 7).

FIGS. 6, 7—Impact craters formed by smaller individuals of the Bruderheim fall, which came to rest on drifted snow. (Photographs by Walker and Balacko.)

Most of the material recovered from Bruderheim was in the form of individuals weighing over 4 kilograms (figure 8). There is a significant grouping of weights around 25–30 kilograms, which seems to be an optimum size for chondrite fragments surviving the penetration of the earth's atmosphere (Lightfoot, MacGregor and Golding 1935), as evidenced by the weight distribution of stones in the British Museum.

FIG. 8—B-37, a perfect individual of the Bruderheim fall, showing details of the fusion crust and an exceptional development of piezoglyphs (thumbprints). (Photograph by Dimitrov.)

TABLE I

LARGE INDIVIDUALS, BRUDERHEIM FALL

U.A. No.	Weight Grams	Pounds	Found Twp. 57 Rge. 20 W4	Now located
B-10	31360	69	Lsd. 12 Sec. 1	Geological Survey, Ottawa
B-14	28600+	63 (68)	Lsd. 5 Sec. 1	University of Alberta
B-12	30300	67	Lsd. 13 Sec. 1	Edmonton Planetarium (on loan from U. of A.)
B-74	25100+	55 (60)	Lsd. 8 Sec. 2	Distributed for analysis
B-13	24420	54	Lsd. 12 Sec. 1	University of Alberta
B-37	17370	38	Lsd. 11 Sec. 2	University of Alberta
B-186	12590	28	Lsd. 16 Sec. 2	Royal Ontario Museum
B-93	10220+	23 (24)	Lsd. 10 Sec. 2	Distributed on exchange
B-102	10165	22	Lsd. 7 Sec. 2	University of Alberta
B-187	7995	18	Lsd. 13 Sec. 10	University of Alberta
B-4	6045	13	Lsd. 2 Sec. 10	University of Alberta
B-38	4560	10	Lsd. 14 Sec. 4	University of Alberta
Total	208725	460		

The statutes of Alberta now contain a clause (embodied in Bill 40 of the 2nd Session, 14th Legislature, Alberta 9 Elizabeth II: A Bill for

the Protection of Historical, Archaeological, Palaeontological, Ethnic and Meteoric Sites and Objects) relating to meteorites:

9. (1) In this section "meteorite" means a stony or metallic body that has fallen to earth from outer space.

(2) Where an object that may be a meteorite falls on any land, whether publicly or privately owned, no person, other than a person authorized by the Minister, shall

(*a*) disturb any crater, furrow or other marking of the earth's surface that may have been caused by the object, or

(*b*) disturb or remove the object from the place where it fell.

(3) The ownership of every meteorite that falls anywhere in the Province after the commencement of this Act is hereby vested in the Crown.

Use

Specimens of Bruderheim have been made available to scientists interested in meteorites, and the fall was early reported in *The Meteoritical Bulletin* by Krinov (1960) from information supplied to Peter M. Millman. Meteorites, it has been said, are the poor man's space probe, and can be made to yield much information on the nature of radiation in space, the origin and nature of the solar system, and indeed of the universe. Results of these investigations have appeared and will be appearing in scientific literature from time to time, and the data accumulating suggests that Bruderheim will be one of the world's most extensively studied chondritic meteorites.

Chemically, Bruderheim is an average chondrite, of the low iron group. The analysis and normative mineral composition are as follows:

TABLE II

CHEMICAL ANALYSIS AND NORMATIVE MINERAL COMPOSITION OF THE BRUDERHEIM METEORITE

SiO_2	39.94		
TiO_2	.12		
Al_2O_3	1.86	*Normative composition*	
Fe°	8.59	Nickel-iron	9.94
FeO	12.94	Troilite	6.38
FeS	6.38	Olivine	41.65
MnO	.33	Hypersthene	25.90
MgO	24.95	Diopside	5.34
CaO	1.74	Albite	8.52
Na_2O	1.01	Anorthite	0.17
K_2O	.13	Orthoclase	0.78
P_2O_5	.29	Chromite	0.92
H_2O^-	.01	Apatite	0.74
H_2O^+	.10	Ilmenite	0.21
Ni°	1.30		
Co°	.05	Analysis by H. Baadsgaard and A. Stelmach	
Cr_2O_3	.60		
C	.04		
Total	100.38		

Summary and Conclusions

A multitude of observations on the Bruderheim bolide, combined with a well defined ellipse of fall, contribute to the documentation of this new Canadian chondrite. Collection is believed to have been reasonably complete and a wealth of recently fallen meteorite material was made available, particularly for the study of short half-life isotopes developed in space as products of cosmic radiation. Chemical, mineralogical, and rare gas studies of the meteorite are under way.

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METEOR NEWS

By Peter M. Millman

National Research Council, Ottawa, Ontario

The I.G.C. (1960) Visual Meteor Programme—Progress Report No. 6

The special visual meteor observations, commenced during the I.G.Y., are being continued at the Ottawa station and also by some of the groups and individuals who co-operated with us so well in 1957–1958. In this report I am glad to welcome some new stations and I hope that a certain number of enthusiasts will continue making observations since we need these visual data for comparison with our radar records.

Previous progress reports have been published in the Journal in vol. 52, pp. 29, 181, 1958; vol. 53, p. 137, 1959; vol. 54, p. 39, 1960; and vol. 55, p. 137, 1961. This report deals with the observations of meteors made during the calendar year of 1960. A summary of these is listed in Table I. The form of the table is the same as that used previously where the station location is followed by the name of the person sending in the observations. The last four columns list respectively the number of different nights on which observations were made, the total number of ten-minute periods covered, the number of meteors seen, and the average number of observers, including timekeeper, working at one time. During the year 7,859 meteors were recorded in 4,877 ten-minute periods. This gives a grand total of 123,742 visual meteors recorded since the beginning of the programme in the summer of 1957. The first part of the table lists stations from which observations have been recorded in previous reports. The second part lists stations which appear here for the first time.

The outstanding contributor to this current report is Mr. F. Wyburn of Red Bluff, California. Mr. Wyburn has been a regular observer since early in 1958 and in previous reports has been responsible for over 1,400 meteors observed. It is quite exceptional, however, for one individual to be able to observe on 261 nights in one year. The only other observer who has approached this record on this programme is Mr. G. Rippen of Des Plaines, Illinois. As will be seen from the table, Mr. Rippen is still sending in a large number of observations.

As noted in a previous report the visual data are all recorded on

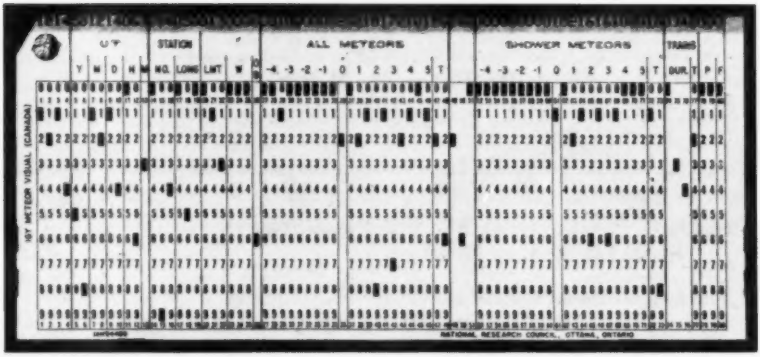

FIG. 1—A typical I.B.M.. punched card recording the details of visual meteors observed from 1:30 to 1:40 E.S.T. on December 14, 1958, at the Springhill Meteor Observatory, Ontario.

I.B.M. punched cards. An example of one of the special cards used on the programme is reproduced in figure 1. This is the actual record of a ten-minute interval during the Geminid shower of 1958, as observed at the Springhill Meteor Observatory. This is station Ottawa, Ont. #1 and is identified by serial number 94.

The first four columns of the card are reserved for a coding which identifies this record as a meteor observation made by a professional group in Ontario, Canada. Following this we have the year 58, month 12, day 14, hour 6, and the ten-minute interval 3, that is 30.0–39.9 minutes. Next we have the station number 94, longitude in hours and tens of minutes 050, local mean time in hours and tens of minutes 013, a three-figure coded weather factor which includes cloud, haze, moon, and artificial light, and in the last column of this section the number of observers working 6. The next 20 columns record the number of meteors seen in each half-magnitude interval. Then we have total meteors 26, total reduced to a standard of six observers 26.0, and a tabulation of shower meteors by magnitude, and total 18. The last few columns give details of any long enduring trains, and the magnitude and other characteristics of exceptionally bright fireballs.

One I.B.M. card corresponds to each ten-minute period observed at each station. Up to the end of 1960 we have a total of 57,486 cards representing in all 9,581 station-hours. A statistical study of the data collected on the visual programme is now in progress. Of particular importance will be the comparison between the visual meteor rates and

the radar meteor rates. The latter are recorded at Springhill on a 24-hour per day schedule and these data have also been transferred to I.B.M. punched cards.

Once again may I express sincere thanks to all those who have given their time and effort to ensure the success of this programme.

TABLE I

SUMMARY OF OBSERVATIONS ON THE SPECIAL I.G.C. (1960) VISUAL METEOR PROGRAMME MADE BETWEEN JANUARY 1, 1960 AND DECEMBER 31, 1960

Location	Name	Nights	Ten-Minute Periods	Meteors Recorded	Average No. of Observers
Des Plaines, Ill.	G. Rippen	28	209	139	1
Edmonton, Alta. #2	E. Milton	2	12	60	7
Elyria, Ohio	G. Diedrich	1	6	15	3
Montreal, P.Q.	E. E. Bridgen	7	52	65	4
Moose Jaw, Sask.	E. Freidin	3	33	309	5
Omaha, Neb.	C. Moroson	2	12	19	2
Ottawa, Ont. #1	B. A. McIntosh	9	315	1,599	9
Regina, Sask.	J. C. Hodges	2	27	135	6
San Jose, Calif.	S. Bieda	1	12	87	4
Houston, Texas #1	D. Milon	2	39	157	5
Red Bluff, Calif.	F. Wyburn	261	3,532	2,972	1
Sheffield, Ala.	R. May	17	99	135	1
Winnipeg, Man. #1	J. Scatliff	1	12	58	4
Montgomery Centre, Vt.	E. E. Bridgen	1	36	343	20
Munro, Jamaica	E. E. Bridgen	1	1	1	1
Siren, Wis.	G. Rippen	4	28	21	1
Calgary, Alta.	B. Bohannan	1	6	47	8
Cochrane, Alta.	J. F. Wright	1	12	51	4
Fort Davis, Texas	D. Milon	4	57	304	4
Halifax, N.S.	B. W. Allen	1	6	9	3
Long Branch, Ill.	G. Schwartz	1	24	95	1
Madison, Wis.	G. Rippen	23	215	316	2
Orangeville, Ont.	J. Kennedy	5	89	534	3
Victoria, B.C. #2 (Duncan, B.C.)	V. L. Stanley-Jones	1	9	109	10
Victoria, B.C. #3	C. Wyatt	3	34	279	7
	TOTALS		4,877	7,859	

NOTES FROM OBSERVATORIES

Dominion Astrophysical Observatory, Victoria, B.C.

The Director, Dr. R. M. Petrie, was awarded the Tory Medal for distinguished contributions to science in Canada at the meetings of the Royal Society of Canada held in Montreal. He gave the Tory Medal Address on "Star Clusters and the Scale of the Galaxy" and also presented papers by R. M. Petrie, Anne B. Underhill and K. O. Wright. Dr. K. O. Wright returned from Toronto early in June to continue his work on stellar line intensities derived from high-dispersion spectra. Dr. Anne B. Underhill returned from Princeton where she worked with Professor Strömgren to adapt methods for computing the flow of radiation through stellar atmospheres to high-speed machine computation.* Mr. W. R. H. White returned to the Seismology Division after spending the academic year at the University of British Columbia; he is working on the crustal structure of south-west British Columbia.

Several appointments to the permanent staff have been made: Dr. A. H. Batten, who resigned his N.R.C. Post-Doctoral Fellowship, Francis Gutmann, who had studied at U.B.C. and McGill, and Richard E. Huffman of Western Washington College of Education. Seasonal appointments were: S. C. Morris and K. Dimoff from the University of Toronto, R. L. Turner and K. J. Rooney from the University of British Columbia, C. D. Hemmings (Seismology) and D. V. Kissinger (Geomagnetism) from Victoria College. Dr. M. W. Ovenden of the Department of Astronomy, Glasgow University, spent four months at the Observatory studying the reflection effects in eclipsing binaries, especially the system 57 Cygni.

R. M. Petrie, K. O. Wright, Anne B. Underhill and A. H. Batten attended the XIth General Assembly of the International Astronomical Union in Berkeley, California from August 15 to 24. Dr. Petrie also attended a symposium on Double Stars for three days immediately prior to the I.A.U. meetings.

The 72-inch mirror was successfully aluminized late in February and the increased reflectivity of the surface has cut down exposure times quite appreciably. Dr. E. H. Richardson, assisted by A. R. Salonen and J. R. White have continued to work on the component parts required for the Coudé spectrograph of the 48-inch telescope. The new telescope

*Dr. G. J. Odgers returned early in September from the Soviet Union where he spent several months under a Canadian–U.S.S.R. arrangement for exchange of scientific personnel.

has been shipped from Grubb-Parsons Co. in England and installation is expected to be completed by early next year.

The Observatory access road was rebuilt during the spring, the new surface and secure guard rail providing improved driving conditions.

REVIEW OF PUBLICATIONS

The Sidereal Messenger of Galileo Galilei, trans. by E. S. Carlos. Pages 111 + vi; $5\frac{3}{4} \times 8$ in. London, Dawsons of Pall Mall.

This is a reprinting of the first English translation of Galileo's *Siderius Nuncius* of 1610, a short, popularly written treatise in which he describes his first telescopic observations, especially those of the moon and the discovery of Jupiter's satellites. Familiar to all students of the history of astronomy, it is a book which should be read by everyone with any interest in the subject. For one thing, it is a beautiful piece of scientific writing, the style of which could well be emulated by scientific writers of today. For another thing, it makes one appreciate the clarity of mind of the great Italian astronomer who not only knew what he saw but was able to draw the dramatic conclusions which toppled the cherished views of two thousand years.

J. F. HEARD

Galileo in China by Pasquale M. D'Elia, S. J., trans. by Rufus Sutor and Matthew Sciasia. Pages 115 + xv; $5\frac{3}{4}\times8\frac{1}{2}$ in. Toronto, S. J. Reginald Saunders and Co. Ltd., 1960. Price $4.30.

The title of this book may seem a little startling. Galileo, of course, was never in China. The title refers, rather, to the promulgation in China of the astronomical discoveries and views of the great Italian astronomer during his lifetime by the astronomers and mathematicians who were among the Jesuit missionaries maintaining stations in China at that time.

The author, Father D'Elia, himself a Jesuit, is Professor of Sinology at the Pontifical Gregorian University and at the State University of Rome. His book is based on hitherto unpublished Jesuit documents and upon Chinese sources not before translated into any European language. The story which it tells is, very briefly, as follows.

Father Ricci, who reopened the gates of China to Europeans in 1583, recognizing the great need of a revision of the then faulty Chinese calendar, continuously besought his superiors in Rome to send him a more competent mathematician or astronomer than himself. Not, however, until after Ricci's death were mathematicians and astronomers sent to China. Among them was Father Shreck who was the seventh elected member (Galileo was the sixth) of the famous Italian scientific *Academy of the Lynxes*. To reform the Chinese calendar, Shreck needed observations which he believed only Galileo could provide. For years he implored the great astronomer to send him these observations, but Galileo ignored the requests rather pointedly—perhaps because of the quarrels which he was having at home with the Jesuits Grassi and Scheiner over the Copernican theory. Ironically it was the Protestant Kepler who, at the first request made of him, supplied Shreck with the needed information.

Despite Galileo's refusal to help them, the Jesuit astronomers in China were his fervent admirers and followers, holding and teaching his new views to the Chinese scholars. Had Galileo known this, he might, says author D'Elia, have been less prone to blame the Jesuits as a group for his tragic condemnation by the church.

Besides the main theme, there are many fascinating sidelights on Galileo and the astronomy of his time in this very interesting and thoroughly documented little book.

J. F. HEARD

NOTES

The Use of a Tape Recorder in Timing Astronomical Observations*

On March 12–13, 1960 the moon was to pass through the cone of shadow thrown in space by the earth—the sun being on one side of the earth, while the moon travelled around the opposite side. The suggestion was made that some of the Winnipeg Centre observers (J. L. Scatliff, John Stewart, Tom Cairns and B. F. Shinn), should time when the edge of the shadow crossed prominent craters on the moon's surface.

Since a visual estimate of the position of the shadow might be open to a difference of opinion, I decided to try photographing the image, timing the photograph exactly. The problem was to devise a way of accurately determining the time of the exposure.

The camera to be used was an Exakta mounted on my telescope. The shutter on this camera makes a charactersitic sound. I found that placing a contact microphone on the camera case gave me an easy way of picking up the shutter sound which could then be recorded on tape. It occurred to me that if I could record on tape the sound of the camera shutter along with the time signals from CHU in Ottawa or from WWV in Washington, the time of a photograph could be determined with considerable accuracy.

This was done with some success. However, the microphone cable which is needed to deliver the signal from the camera to the recorder some hundred feet away tends to be unreliable. An improvement in technique was made for the observation of the partial eclipse of the sun on September 20, 1960. To avoid using the unreliable microphone cable it was decided to use amateur radio to deliver the signals from the camera. This has proven highly practical with the co-operation of Wesley Harvison, VE4GN, and W. T. Loftus, VE4TL.

When a tape recorder is used, visual observations, the number of a photograph, etc. can be recorded along with the time signals. Since the timing pulses are completely regular they can be deciphered even if momentarily obliterated by voice. Afterwards the tape can be run by hand to locate a known pulse and the point marked with grease pencil; similarly the camera pulse and the next identifiable time pulse can be marked on the tape. The tape can then be removed from the machine, stretched out, and the distances measured between the marks to derive the time of the photograph within the accuracy of the marks and the distance between the time pulses.

B. F. Shinn

*Adapted from a lecture by B. F. Shinn delivered to the Winnipeg Centre on October 24, 1960—Editor.

Donation to Calgary Centre

The Moonwatch and Phototrack groups of the Calgary Centre take pleasure in announcing the receipt of a generous cash donation from Dr. T. A. Link, President of the consulting firm of Link Downing Cooke and Company Limited, and first Honorary President of the Calgary Centre of the Royal Astronomical Society of Canada. T. A. (Ted) Link has been actively associated with a number of geological and scientific societies and has been the recipient of many awards in recognition of his efforts.

Moonwatch and Phototrack groups are engaged in visual observation and photographic tracking of artificial earth satellites in co-operation with the Smithsonian Astrophysical Observatory of Cambridge, Mass. These groups are part of a world-wide network of some 90 volunteer teams. In addition to routine tracking assignments, the groups take sightings of newly-launched earth satellites in their initial orbits, conducting searches for "lost" satellites, providing visual support for tracking space probes and carrying out co-ordinated research programmes with other groups. The Calgary teams are on a permanent alert for U.S.S.R. satellite launchings. Co-operation with the Western Satellite Research Network in the U.S. on projects under the guidance of North American Aviation is currently planned.

The Moonwatch and Phototrack groups are manned entirely on a volunteer basis; acquisition of the necessary observational equipment has been the responsibility of the participating individuals. As a result, much of the apparatus has been makeshift, inadequate and unreliable, except for the basic instruments supplied by the Smithsonian Astrophysical Observatory. Dr. Link's contribution has provided the group with the necessary funds for acquiring dependable equipment.

A. F. McQuarrie

VARIABLE STAR NOTES

By Margaret W. Mayall

The American Association of Variable Star Observers, Cambridge, Mass.

The A.A.V.S.O. 50th Anniversary celebration was launched with a most enjoyable and successful Spring Meeting in Ottawa, Ontario, on the 26th and 27th of May 1961. About a hundred members and guests gathered for the occasion, making it a record or near record attendance for a spring meeting.

The meeting was held at the very kind invitation of the Ottawa Centre of the Royal Astronomical Society of Canada. Headquarters for the meeting was in one of the beautiful new buildings of the Radio and Electrical Engineering Division of the National Research Council of Canada. Dr. B. G. Ballard, Vice-President of the National Research Council and Director of Radio and Electrical Engineering, Dr. Ian Halliday, President of the Ottawa Centre, and Dr. Peter M. Millman, President of the R.A.S.C. and a member of the A.A.V.S.O. Council, took part in the welcoming ceremonies.

The Council announced the following list of 36 people who were elected to Annual membership in the A.A.V.S.O. William Abbey, *Florida*; Asociacion Chilena de Astronomia, *Chile*; Timothy Brown, *Arizona*; J. G. Craig, *Canada*; William De Forge, Jr., *New Jersey*; Richard M. Fox, *Pennsylvania*; Robert E. Fried, *Georgia*; Bruce E. Gardner, *Pennsylvania*; G. L. Gray, *Canada*; Walter R. Hampton, *Vermont*; Hideo Honda, *Japan*; John R. Hostetler, *Washington*; Junior Science Research Organization, *Pennsylvania*; Stanley Kellogg, *California*; Paul Knauth, *Texas*; Charles E. Kratz, *Maryland*; Don Lammon, *California*; Mario Loocks V., *Chile*; Ernest O. Lorenz, *California*; Donald S. Lund, *New Mexico*; Franklin F. Marsh, *Massachusetts*; David L. Patt, *Texas*; Joao Luis Quininha Pena, *Portugal*; Leonard E. Pohler, *Texas*; James Randi, *New York*; G. O. Rawstron, *England*; Mario Restrepo C., *Colombia*; James A. Ruth, *New York*; Michael L. Sander, *California*; Schreiber Astronomy Club, *New York*; Lee D. Schur, *California*; Robert Kenneth Shayler, *Texas*; Christopher Spratt, *Canada*; Raymond R. Thompson, *Canada*; Luther B. Wicks, *New Jersey*; Worthington Astronomy Club, *Ohio*.

A highlight of the meeting was a lecture by Dr. M. G. Whillans, Assistant Chief Scientist, Defence Board of Canada, on "Bioscience and Space Research." He held the large audience entranced as he told of his experiments with plant life under different gravity forces.

The Staffs of the National Research Council scientific laboratories were very gracious hosts to the A.A.V.S.O., and were on hand to explain and demonstrate the research being done. In addition to the Montreal Road Laboratories in Ottawa, trips were arranged to visit the Radio Astronomy station at Goth Hill, the Springhill Meteor Observatory, and the Dominion Observatory.

At the session for papers on Saturday morning, we were privileged to hear talks describing the work of the various stations we were to visit. These talks made the visits to the stations very much more interesting, and our guides at the stations appreciated having guests who had already been briefed on some of the work.

Summaries of the papers presented at the meeting are printed in the A.A.V.S.O. Abstracts. Among the papers were "RZ Cassiopeiea" by John J. Ruiz, a résumé of the results obtained as a result of a programme suggested by Dr. Ashbrook in *Sky and Telescope* magazine. RZ Cas is an eclipsing variable with a period of about 48 hours.

Visual, photographic and photoelectric determinations of the times of minimum were compared and found to agree remarkably well. They showed that a good value for the period of an eclipsing variable may be obtained from the mean of a number of visual observations. Mr. Ruiz demonstrated an artificial eclipse with his photoelectric equipment, and showed some of his beautiful light curves of eclipsing variables.

Lewis J. Boss contributed a paper entitled "A Source of Standard Time Signals," in which he discussed various radio signals and receivers. Mr. Boss referred to an article in the August 1960 issue of *Electronic Industries* magazine which gave a circuit diagram and instructions for building a 5 megacycle transistorized receiver. It has a 2-inch speaker and is small enough to be carried in the coat pocket.

Margaret Mayall gave a brief description of the group of large blueprints of light curves which were on exhibit. Among them were the light curve of R Coronae Borealis from 1845 to 1961, and a detailed plot of its 1960 minimum; curves of Nova Herculis 1960 and the recurrent nova RS Ophiuchi; and a plot of the curve of the semi-regular bright variable W Cygni for 1916 through 1960. Emphasis was put on the need for more observations of many of the bright semi-regular red variables similar to W Cygni.

Supernova NGC 4564. On May 9, 1961, Dr. G. Romano at Padua, discovered a supernova in the galaxy NGC 4564. It was superposed almost on the centre of the nucleus, and photographic observations proved very difficult. Thomas Cragg, while working on it at Mount Wilson Observatory, noticed that visually it was quite easy to distinguish the sharp image of the supernova from the hazy nucleus. Mr. Cragg made a chart of the region and a few of our observers were able to observe it for over a month. It decreased gradually from 11.7 on May 15, to 12.0 on May 22, and 12.5 on May 30, to about 13 in the middle of June. By that time the supernova was difficult to separate from the nucleus. This was undoubtedly the most distant star our observers have ever been able to see, as the galaxy is about 33 million light-years away.

There are several large photographic surveys for supernovae in progress, but it appears to be a field in which the visual observer can also take part. The accompanying table lists 55 supernovae in 46 NGC objects. Parentheses in the third column indicate photographic magnitudes instead of visual. The magnitudes of the supernovae are very approximate because many were not found until they had passed maximum.

It is suggested that observers select a few galaxies to be checked at every opportunity. The A.A.V.S.O. plans to prepare a list of those easy to find with moderate size telescopes, but in the meantime, there are many sources available. For example, the list in the R.A.S.C. *Observer's Handbook*, a list of Messier objects, the deep-sky objects in *Sky and Telescope*, and galaxies marked on various atlases. A report should be sent to the A.A.V.S.O. the first of each month, listing the name of the galaxy and each time of checking. Stephen Burt has started checking NGC 3626 (M66) and NGC 4736 (M94), and several other observers are setting up programmes.

A.A.V.S.O. Nova Search Report (from George Diedrich, Chairman). Observations of nova search areas were made by the following 25 observers for a total of 454 area-nights reported. Each name is followed by the number of observations made in March and then April, 1961: N. Amor—5, 9; J. G. Avery—49, 26; Mrs. E. E. Bridgen—15, 9; F. J. DeKinder—9, 9; I. P. Debono—0, 2; D. Diedrich—6, 2; G. Diedrich—6, 2; W. Isherwood, Jr.—11, 14; J. Low—6, 6; H. C. Nightingale—0, 24; D. W. Orchiston—11, 3; R. Price—12, 0; W. S. Renn—0, 20; J. R. Ritson—0, 10; E. K. Sharrock—6, 36; R. C. Shinkfield—4, 0; G. W. Smith—16, 4; F. Traynor—16, 27; T. B. Tregaskis—10, 10; G. Vodrazka—0, 6; D. Ward—9, 7; W. A. Warren—12, 0; K. A. Wells—12, 0; I. K. Williamson—2, 5; K. Zorgo—6, 0.

In addition the following observations have not been previously reported: two in December 1960 by K. Zorgo and seven in February 1961 by T. B. Tregaskis.

TABLE OF SUPERNOVAE

N.G.C.	Type	Mag. vis.	1950 position h m	° ′	Supernova	Max.
224	Sb	4.8	0 40.0	+ 41 00	1885	6.5
253	Sc	8.9	45.1	− 25 34	1940	14
1003	Sc		2 36.1	+ 40 18	1937	12.8
1365	SB	(11.2)	3 31.8	− 36 18	1957	—
1482			52.4	− 20 39	1937	14.5
2535	S	(12.9)	8 8.2	+ 25 36	1901	13.3
2608	S	(12.9)	32.2	+ 28 38	1920	11.8
2672/3	E	12.2	46.6	+ 19 16	1938	15.5
2841	Sb	9.3	9 18.6	+ 51 12	1957	14
3177	E	(12.8)	10 13.9	+ 21 22	1948	14.5
3184	Sc	12.1	15.2	+ 41 40	1921, 21, 38	13.4, 11.1, 13.5
3254	Sc	12.2	26.5	+ 29 45	1941	14.2
4096	Sc	11.9	12 3.5	+ 47 45	1960, 60	14, 14.5
4136	S	(12.1)	6.7	+ 30 12	1941	16.8
4157	Sc	11.9	8.6	+ 50 46	1937	14.6
4214	I	10.3	13.1	+ 36 36	1954	9.0
4273	Sb	11.6	17.4	+ 5 37	1936	14.2
4303	SBc	10.1	19.4	+ 4 45	1926, 61	13.3, 13
4321	Sc	10.6	20.4	+ 16 6	1901, 14	12.4, 14
4374	E	9.3	22.6	+ 13 10	1957	13.4
4382	E	9.3	22.8	+ 18 28	1961	13
4424	S	(12.6)	24.6	+ 9 42	1895	12.5
4486	E	9.2	28.3	+ 12 40	1919	12.3
4496	S	(12.0)	29.1	+ 4 12	1960	12
4527	S	(11.3)	31.6	+ 2 56	1915	13.0
4545			32.4	+ 64 14	1940	15.0
4559	Sc	10.6	33.5	+ 28 14	1941	13.5
4564	E	(12.1)	12 34.0	+ 11 43	1961	11.5
4621	E	9.6	39.5	+ 11 55	1939	11.8
4636	E	10.4	40.3	+ 2 57	1939	12.3
4674			43.4	− 7 56	1907	13.5
4725	SBb	8.9	48.1	+ 25 46	1940	12.5
IC 4051	E		58.5	+ 28 43	1950	17.7
IC 4182	S		13 3.5	+ 38 19	1937	8.3
5195	I	8.4	27.9	+ 47 31	1945	11.0
5236	Sc	(8.0)	34.3	− 29 37	1923, 50, 57	14.0, 14.5, 16
5253	Sa	(10.8)	37.1	− 31 24	1895	7.1
5457	Sc	9.6	14 1.4	+ 54 35	1909	12.1
5668	S	(12.4)	30.9	+ 4 40	1954	12.8
IC 1099	S		15 5.8	+ 57 0	1940	16.3
5879	Sb	(12.1)	8.4	+ 57 12	1954	14.5
5907	Sc	11.3	14.6	+ 56 31	1940	13.5
6181	Sc	11.9	16 30.1	+ 19 56	1926	14.2
IC 4652			17 22.1	− 59 36	1935	15.0
6946	S	(11.1)	20 33.9	+ 59 58	1917, 39, 48	12.9, 13.2, 14.8
7331	Sb	9.7	22 34.8	+ 34 10	1959	12

Observations received during May and June 1961: A total of 6,898 was received: 4,306 from 102 observers in May, and 2,592 from 72 observers in June.

Observer	May		June	
	Var.	Ests.	Var.	Ests.
Adams, R. M.	86	152	97	172
Aguirre, V. H.	4	7	...	...
Anderer, J. A.	1	1	8	12
Anderfhuren, E.	13	13	...	...
Anderson, Carl	26	37	11	11
Anderson, Curtis	7	15	3	4
Axelson, K.	5	5	3	3
Ayala R., H.	13	19	7	7
Barrera, S.	2	2	...	...
Bieda, S. W.	3	30	...	...
Bradley, D. A.	91	91	79	83
*Brady, R. F.	31	41	5	5
Buckman, B. K.	1	18	2	15
Buckstaff, R. N.	16	52	...	...
Burt, S. E.	10	18	2	3
Celis S., L.	3	36	...	...
Cragg, T. A.	144	145	215	225
Craig, J. G.	...	...	6	8
de Buen, J.	2	2	...	...
De Forge, W.	1	1	4	5
de Kock, R. P.	124	572	...	...
de la Vega L., R.	64	424	...	...
Diedrich, DeL.	2	2	1	1
Diedrich, G.	2	4	2	3
†Engelkemeir, D.	7	13	6	11
Erpenstein, O. M.	8	8	1	1
Fernald, C. F.	142	226	139	273
Fernandes	7	19	...	...
Fernandez, G.	1	7	...	...
Figueroa Z., R.	1	4	...	...
Frogel, J. A.	2	2	...	...
Fuller, K.	34	35	...	...
Gardner, B. E.	5	5	...	...
Gonthier, A.	29	63	17	26
Gonzales, R.	13	18	...	...
Hampton, W. R.	3	6	2	4
Hartmann, F.	125	132	117	121
Hicks, R. L.	6	29	4	18
Hidalgo, A.	13	13	...	...
Hiett, L.	...	...	4	6
Honda, H.	57	106	23	27
Houston, W. S.	...	...	51	62
Hurless, C.	21	68	33	76
Hutchings, N. O.	6	6	...	...
Kelly, F. J.	12	20	15	20
Knauth, P.	11	12	...	...
Knowles, J. H.	6	7	6	13
Lacchini, G. B.	28	83	24	44
Lehmann, P. B.	20	50	...	...
Lewindon, F.	1	1	...	...
Loblay, R.	3	12	2	4
Lorenz, E. O.	6	8	9	9
Lucas, D.	12	28	3	6
Lynch, J. S.	6	6	...	...
Maran, S. P.	1	1	8	8
Martinez G., A. E.	3	18	...	...
Masuch, J.	9	33	...	...
McPherson, C. A.	13	13	14	14
Menzel, K.	...	...	5	18
Meynet, A.	6	40	...	...
Miller, R. W.	13	14	9	9
Miller, W. A.	28	33	34	50
Montague, A. C.	17	22	27	46
Morgan, F. P.	14	24	10	15
Morrow, E. O.	9	9	...	...
Mourilhe S., P.	16	38	11	28
Muniz B., L.	4	5	2	3
Newton, C. S.	1	1	1	1
Nightingale, H. C.	...	...	7	26
Oberstatter, A.	...	...	15	18
Olmsted, M.	8	8	6	7
Oravec, E. G.	82	111	106	170
Orchiston, D. W.	36	199	...	...
Ortiz, E.	13	18	...	...
Pearlmutter, A. E.	4	4	15	15
Peltier, L. C.	39	203	33	120
Pena, J. L. Q.	8	19	...	...
Peña V., J.	12	63	...	...
Peters, P. J.	26	26	9	9
Price, R. T.	13	45	...	...
Quester, W.	7	20	...	...
Ragland, B. S.	1	11	1	10
Rawstron, G. O.	8	21	9	16
Renner, C. J.	...	...	155	222
Rizzo, P. V.	13	15	6	9
Robinson, L. J.	1	1	3	6
Rocha, N.	2	2	3	3
Rosebrugh, D. W.	11	23	6	28
Salce M., H.	5	6	...	...
Schiff, S.	6	7	23	34
Sealy, R. N.	...	...	6	7
Seavey, H. O.	8	13	...	...
Sharpless, A. P.	24	24	22	22
Shayler, R. K.	11	15	3	5
Sheldon, L.	7	8	...	...
Sherwood, D. A.	4	10	7	9
Shinkfield, R. C.	27	162	16	39
Smith, G. W.	6	6	...	...
Smith, J. R.	...	...	9	10
Sobrinho, M.R.deC.	4	4	2	2
Solano, S.	13	18	...	...
Specht, H. E. M.	3	3	...	...
Spratt, C.	12	39	13	73
Staer, R. R.	...	...	1	2
Taboada, D.	74	82	110	118
Tavares, O. C.	3	3	5	10
Thomas, M. A.	...	...	1	2
Topp, G.	4	7	...	...
Traynor, F. N.	5	5	15	25
Tsai, C. H.	24	51	...	...
van Zyl, L. L.	43	110	48	77
Vodrazka, G.	6	11	10	28
Williamson, P. L.	4	8	...	...

*7^m AD Leo, 7^m WX UMa

†17^h 36^m AD Leo

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Vol. 55, No. 5 **OCTOBER 1961** **Whole No. 452**

William Ross Hossack, 1927–1961 ..... *John F. Heard* 201
An All-Sky Camera for Auroral Photography ..... *F. R. Park* 203
The Paths of Solar Eclipses ..... *Charles H. Smiley* and *Fred F. Czarnec* 211
The Bruderheim Meteorite—Fall and Recovery .. *R. E. Folinsbee* and *L. A. Bayrock* 218

METEOR NEWS ..... *Peter M. Millman* 229

NOTES FROM OBSERVATORIES 232

REVIEW OF PUBLICATIONS
The Sidereal Messenger of Galileo Galilei trans. by E. S. Carlos; *Galileo in China* by Pasquale M. D'Elia, S.J. 233

NOTES 235

VARIABLE STAR NOTES ..... *Margaret W. Mayall* 237

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16

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